NOTES ON SOME PROBLEMS OF ADAPTATION: 5. THE PHOTOTROPISM OF LIMA.[1]

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The monomyarian lamellibranch *Lima* is said (Kafka, '14, p. 393) to be "photoptic," *i.e.*, reactive to light but not to shadows. The statement may be applied to the species of *Lima* found in some abundance at Bermuda, but there are certain additional features about the photic responses of this animal which merit a more extended notice.

Polimanti ('12) has distinguished three types of locomotion in *Lima hians:* (1) by the use of the foot as a lever; (2) by closure of the valves and retraction of the tentacles (Butler, '91); (3) by the expelling of water through the siphons. The first of these types may however have some complex aspects.

Lima was usually obtained near low water, around the edges of large stones, and among smaller stones piled together loosely, in bays where a certain amount of silt was being deposited; but was also encountered on the reefs, in crannies between corals, and sometimes among colonies of *Ecteinascidia.* It is decidedly photonegative in its behavior, although this activity may be lost after some days of laboratory captivity in open dishes. The edge of the mantle is beset with long tentacles, which are only very slightly adhesive toward wood or glass, but upon which carmine particles stick and accumulate readily. When touched, these tentacles react individually, by a vigorous and complicated retraction, but the reaction time is curiously long (about 1 minute, after a vigorous prod). They are reactive also to strong currents of sea water, and respond vigorously to the local application of a gentle stream of fresh water. At rest, the long white tentacles are widely extended (for a good figure, cf. Nutting, '19, p. 93). The tentacles are quite sensitive to weakly acid solutions; and, after the animal has been for a time in darkness,

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illumination seems to cause a variable number of them to curl and contract, but not sharply; they do not themselves appear locally sensitive to light. Stimulation of a tentacle by weak acetic acid in sea water caused the particular tentacle to retract instantly, and the animal to immediately swim violently away.

In swimming, *Lima* has open to it a variety of possibilities. It may progress while lying on either side, after the manner of *Pecten*, or it may swim with the medial plane in the vertical position, the animal being out of contact with the substratum save between "steps." The "steps" may in either case be made in one of several ways—either toward the gape of the shell, as with *Pecten*, in which event the mechanics of the swimming act is similar to that of *Pecten* (Vlès, '06; Bauer, '12); or else toward the hinge, by squirting water from between the valves. The mantle fold is relatively wider than in most Pectinidæ, and is very mobile; at rest, it beats with a rhythmic pulsation, doubtless functionally homologous with that known in some other lamellibranchs (Redfield, '17), but different in one regard: in *Anodonta* and in other clams the opposite mantle-flaps beat synchronously, whereas in *Lima* they unmistakably pulsate in opposite phase, alternately.

The *Pecten*-like mode of progression is the one usually adhered to, whether the animal be swimming vertically or on one side (and by actual count it was found that either side is used, indifferently). This is almost the only type of swimming induced by photic stimulation, the other mode of progression, in the direction of the hinge, being slower and made up of very short "steps."

When a previously darkened *Lima* is illuminated by horizontal sunlight, it turns the gape away from the light and swims, usually with the valves vertical, in a straight line away from the light. There is exhibited a definite and peculiar process of orientation. The long, mobile foot is thrust out between the valves, its free portion is bent sharply away from the light, and its distal end becomes adherent to the substratum. The foot then shortens longitudinally, so that, without moving its valves, the body is turned somewhat away from the light; several

"steps" of this sort, perhaps three in all as a rule, result in an almost perfect alignment of the median plane in the axis of the light beam; the *Lima* then swims, *Pecten*-wise, in a straight line away from the light. The swimming act is not usually prolonged, perhaps 50 cms. representing the maximum distance covered before temporary exhaustion intervenes, but the orientation process is of a definite, clean-cut character and was previously unknown, so far as I am aware, among bivalves. It is a point of some interest that in a photosensitive form such as *Lima*, where structural conditions give the possibility of phototropic behavior, we do in fact find such behavior diagrammatically exhibited.

The process of body-orientation is usually as just described; but if light be directed upon the gape of a vigorous *Lima* it sometimes gives a violent somersault, turning completely through 180° by some mechanism which I was not able to analyze; the subsequent swimming is in the usual manner.

I tried to find out if the foot, so active in the commoner orientation process, were itself photosensitive. After various trials with local illumination I came to the belief that it was, but complete proof of this I did not secure.

It is especially when the animal is weakened by handling or by laboratory conditions that swimming on the side is found. When in good condition a *Lima* can swim for at least 25 cms. through the water without touching substratum.

The photonegativity of *Lima*, involving so curious a method of orientation, is obviously important in maintaining these animals in crannies and darkened clefts, under stones and among coral heads.

Summary.—The bivalve *Lima* is photonegative, and in vigorous individuals the response to illumination involves a true and accurate orientation of the body, with gape away from the light, by means of the long adhesive foot, which is itself perhaps photosensitive; orientation is followed by *Pecten*-like swimming, the valves being vertical.

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